GREAT LAKES ICE SEASON OF 1967

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ABSTRACT

Methods of ice observation and analysis are described and discussed. Ice coverage charts for each 10th day of the 1966–1967 season are presented. It is concluded that data now exist to begin the construction of a much needed ice climatology.

1. INTRODUCTION

The Great Lakes constitute the largest reservoir of fresh water in the world. Near their shores are located some of the most heavily populated sections of both the United States and Canada. All meteorologists and most laymen living in the Lakes Region well recognize the controlling effect of the Lakes on local climate. Ice on the Lakes also profoundly affects weather conditions, and the amount of ice varies considerably from year to year. However the forecaster has little information on the current distribution of ice, and the scientific investigator knows little about the normal distribution. Both a rapid means of ice reporting and an ice climatology are much needed.

The paucity of ice data has limited previous studies to small portions of the Lakes (Richards [1], [2]; Heap [3]; Heap and Noble [4]) or to generalized summaries (Oak [5]). In recent years the amount of available data has increased considerably, though much remains to be desired. For many years useful weather forecasts have been prepared from meteorological data that are not really adequate. It appears that the time has come when the synoptic meteorologists' tools of extrapolation and interpolation might be successfully applied in the preparation of useful ice analyses of the Great Lakes. It is the purpose of this study to present such an analysis of an entire winter season, as a first step toward assembling the data on which an ice climatology might be based.

2. ICE OBSERVATIONS

The conflicting data found in most series of ice observations can drive an investigator to distraction. Actually we have asked our observers to do what is not possible—to describe the ice adequately without getting very close to it. A completely adequate ice observation can be made only by going onto the ice with all the necessary tools to measure it and determine all its physical characteristics. This is inconvenient and sometimes dangerous, and the number of such samples required would be prohibitively large.

The ice observing program must then be a melange of every possible source of information, taken with a large dose of skepticism, and integrated by intuitive reasoning to resolve the inevitable inconsistencies.

Each type of observation used in the 1967 Ice Program is described and discussed below.

STATIONARY ICE REPORTERS

Observers are mostly persons employed in marine industries, located in harbors or at strategic points along waterways. Report cards are mailed each Friday, and at other times when significant changes occur. Occasional very important reports are telegraphed or telephoned. Observations usually include ice thickness, although there has been no standardization of methods of sampling, measuring, or estimating. These are by far the most valuable reports of ice conditions in rivers and harbors. Information is also included on ice in nearby lake areas. This is also much needed, and it is used. However, it is apparently quite difficult for an observer to estimate accurately the distance to, or extent of, any open water he can see. Conflicting evidence is often at hand, and differences must be resolved.

COMMERCIAL SHIPPING

A small amount of shipping continues through the winter in areas of relatively little ice. Officers on these boats mail in ice report cards similar to those of the stationary observers. They give some information on ice coverage, and occasionally ice thickness, in mid-lake regions. These reports are valuable, but the extent of coverage is minimal.

COAST GUARD CUTTERS

As soon as the ice begins to deteriorate in the early spring, Coast Guard cutters begin their icebreaking work of opening and maintaining channels. While engaged in this work, they transmit detailed ice reports by radio, usually several times a day. These include coverage, thickness, and condition of the ice and its effect on navigation. These are the most valuable of all types of ice reports. Unfortunately they are available only during the breakup season, and they do not cover the entire Lakes Region.

AERIAL ICE RECONNAISSANCE

Throughout the ice season reconnaissance flights are operated, as aircraft are available and as weather conditions permit, by the Canadian Meteorological Service and the U.S. Lake Survey. Highly trained and experienced ice observers give the most detailed and reliable reports on ice coverage. Unfortunately the flights are rather infrequent. Individual flights or series of flights will normally cover 20 to 50 percent of the Lakes' surface.

PILOT REPORTS

Crew members of aircraft operating over the Lakes for purposes other than reconnaissance often report observed ice conditions. These are rudimentary observations, offering little detail, but they are often quite timely and sometimes give the first indication of a sudden change.

METEOROLOGICAL SATELLITES

Photographs taken by ESSA and NIMBUS satellites are available. They have the potential to give the most timely and complete information on ice distribution in mid-lake areas. The high percentage of cloud cover over the Great Lakes in winter restricts the frequency of observation. During the 1967 season cloud cover over Lake Superior was much less than expected, and many useful satellite photographs of that Lake are available. Interpretation of ice features shown on these photographs presents many problems, some of them far from solution. The satellite makes a direct measurement of nothing more than albedo. The relationship between the amount and firmness of the ice and its albedo is far from linear, and is poorly understood. The darkest areas of the pictures may be open water, thin new ice, moderately thick ice without snow cover, or ice of any thickness with water on top. The brightest areas are usually solid fast ice with thick snow cover, but fresh slush or even an occasional sun glint from open water will give about the same appearance. Shades of gray are associated with partial ice cover, but not in any simple relationship. Ice topography, aging and deterioration, and partial snow cover all have their varying effects on the albedo.

3. ICE DISTRIBUTION CHARTS

Charts showing the distribution of ice cover over the entire Great Lakes System for each 10th day of the 1967 ice season are presented (figs. 2–14). Ice concentration is shown by a symbolic shading code (fig. 1) which is a simplified version of the code used for aerial reconnaissance reports.

It is impossible within the limits of any publication to present all, or even a large fraction, of the data used. In order to show the nature and the amount of data available a selection of the material on which the chart for March 21 was based is presented.

The following photographs from the ESSA IV satellite were used: Pass 646, March 18, 1524 GMT; Pass 659, March 19, 1553 GMT; Pass 710, March 23, 1625 GMT; Pass 722, March 24, 1507 GMT.

Canadian Icerec charts for March 15, 16, and 17 were used as were U.S. Lake Survey ice charts for March 17.

The following pilot reports were available, both dated March 20:

BUF 20100E

ALREPS 0800E ICE REPORT CLE TO BUF. SOLID ALL THE WAY. SOME SEPARATIONS ALONG SOUTH SHORE WHICH PILOT THINKS MAY BE THE RESULT OF ENTIRE FLOE SHIFTING NORTH.

CLE PIREP YZ TO CLE OVR LAKE ERIE

NORTHERN ONE THIRD LAKE ERIE SOLID. SOUTHWARD FROM THIS LINE EAST-WEST CHANNELS 50 TO 100 FEET WIDE.

The reports received from stationary ice reporters are given in table 1. The report from Ludington, Mich., relays information from commercial shipping; the report from Port Arthur, Ontario, relays information from an airline pilot. A card received directly from the steamer *City of Milwaukee* on March 17 gave the following: "Muskegon—no ice in outer harbor or channel. Open water in center of Muskegon Lake. Ice 5″ thick along shore of Muskegon Lake."

The following ice reports were received from Coast Guard cutters:

201530Z MESQUITE

STURGEON BAY X FAST FIELD BLUE X 18/1 X TEN X ICEBREAKERS.

201714Z SUNDEW

FM CHARLEVOIX TO LIMIT OF VISIBILITY 10 MI X DRIFT X FIELD X BLUE X WINDROW X 8–10 X SEVEN X ICEBREAKERS.

201715Z BRAMBLE

BASE DETROIT TO WINDMILL POINT UNOBSTRUCTED. THENCE TO LK ST CLAIR LB2 ICE JAMMED AND WINDROWED 6–12/0. THENCE TO LK ST CLAIR BUOY 17 DRIFT FIELD BLUE WINDROW 4–8/0 TEN ICEBREAKERS WITH HEAVY JAM IN VICINITY OF BUOY 17.

202044Z BRAMBLE

FROM SOUTHEAST BEND LT 20 TO LAKE ST CLAIR CUTOFF CHANNEL LT2 DRIFT BRASH BLUE 2–10/0 TEN STEAMERS ICE FIELD BROKEN BUT NOT MOVING THENCE TO LAKE ST CLAIR LT FAST FIELD BLUE WINDROW 3–6/0 ICEBREAKERS THENCE TO LAKE ST CLAIR BUOY 10 DRIFT FIELD BLUE 10–15/0 TEN ICEBREAKERS THENCE TO PEACH ISLAND FRONT RANGE LIGHT FAST FIELD BLUE 6/1 NINE ICEBREAKERS THENCE CG BASE DETROIT DRIFT FLOE BLUE 3/1 FIVE.

202138Z OJIBWA

LAKE ERIE, NO CHANGE. OPEN TRACK TO A POSITION 232 DEGS, 5.5 MILES FROM BUFFALO HARBOR LT.

202305Z MESQUITE

STURGEON BAY OUT SIDE TRAC X FAST FIELD BLUE X 24/3 X TEN ICEBREAKERS.

Approximately 80 percent of the data presented above were available in time to be used for operational charts prepared during the ice season. With existing communications facilities, operational charts are completed about 3 days after the observations are taken. During the winter of 1966–1967, these charts were prepared weekly from mid-December through January, every third day during February, and daily for the remainder of the season. Operational charts were based on whatever information was available at the time of preparation. They were usually incomplete and many of them were radically altered in post analysis. The selected charts presented here (figs. 2–14) are based in part on those operational charts. Many valuable data which came in too late for operational use have been consulted. Winds and air temperatures have been studied in an attempt to understand observed changes, and in some cases to fill in areas devoid of observations. Lapses in reasonable continuity have been corrected wherever actual data will allow.

Cases of conflicting data were resolved by considering the various types of reports in the following order of preference: 1) aerial reconnaissance, 2) Coast Guard cutters, 3) satellite photographs, 4) pilot reports, 5) commercial shipping reports, 6) stationary ice reporters, 7) other sources (newspaper articles, etc.). Remaining gaps were then filled by deductive reasoning based on continuity from earlier analyses, temperatures and winds, and what little is known of ice climatology.

4. THE 1967 ICE SEASON

Water temperatures are measured at a few feet below the surface in most major Great Lakes ports. By the first week in December 1966 most reported temperatures were lower than the temperature of maximum density. However, strong winds still produced temperature rises in the water along downwind shores and temperature falls along upwind shores, indicating the presence of the summer thermal regime with a thermocline still persisting in the open lake. The storm of December 9 and 10 did this. Those of the 19th and 20th and of the 22d and 23d had little effect on water temperatures. The Christmas Day storm brought the first general cooling throughout the Lakes. It is thus concluded that the autumn overturning occurred between December 15 and 20.

Freezing degree-days occurred in the northern Lakes Region the last week in November and were prevalent throughout the Lakes by early December. Any ice that formed in shallows during this period must have soon disappeared, for there is no evidence at all of its existence. A low-pressure area moved through the upper Lakes on December 17 and dropped several inches of snow. Clearing skies on the 18th exposed the first definite evidence of ice cover to the satellite's camera. Snow cover was visible on Black Bay, most of Nipigon Bay, and about the northeast half of Thunder Bay, all in northern Lake Superior. Ice in these northern Bays was now strong enough to support a snow cover and the season was underway.

The shipping season on the Great Lakes officially terminated December 16, 1966. However, most vessels tried, as usual, to get in one more trip. Some of the last boats to leave Lakehead Harbour, on December 23, had moderate difficulty with ice. Ice formed rapidly in all shallows during the cold weather of the last part of December. By the end of the month it was 6 to 7 in. thick on Saginaw Bay. Much of the newly formed ice was blown away from shore and melted. Ice in landlocked areas and restricted channels was often broken up into pancakes or brash, which sometimes accumulated a layer of snow or slush and then refroze into jagged conglomerates. On December 29 barges operating between Detroit and Toledo made an unusual early season request for icebreaker assistance.

The first of the series of ice cover charts shows conditions on the last day of 1966 (fig. 2). Landfast ice is present in the northern bays of Lake Superior, in portions of the St. Mary's River and North Channel, in Saginaw Bay, and in Anchor Bay of Lake St. Clair. Fields and floes are present adjacent to these areas and in many other shallows. Ice lies mostly on the upwind sides of the Lakes except in Lake Superior. Apparently the water in at least the western part of Lake Superior is now cold enough to allow drifting of floes from the north to the south shore.

The storm of January 7 destroyed much drift ice, and deposited a substantial snow cover on much of the fast ice in the northern regions. This snow cover, which later increased, provided insulation against the cold weather that was to follow. Ice at many places in this area failed to reach its normal thickness, and the spring breakup was accelerated. (See figure 3.)

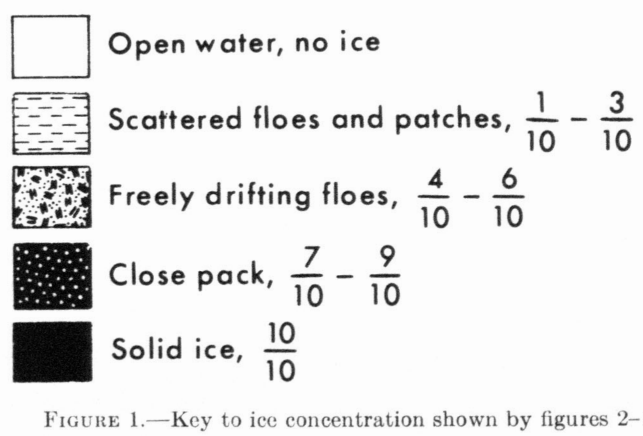

FIGURE 1.—Key to ice concentration shown by figures 2–14.

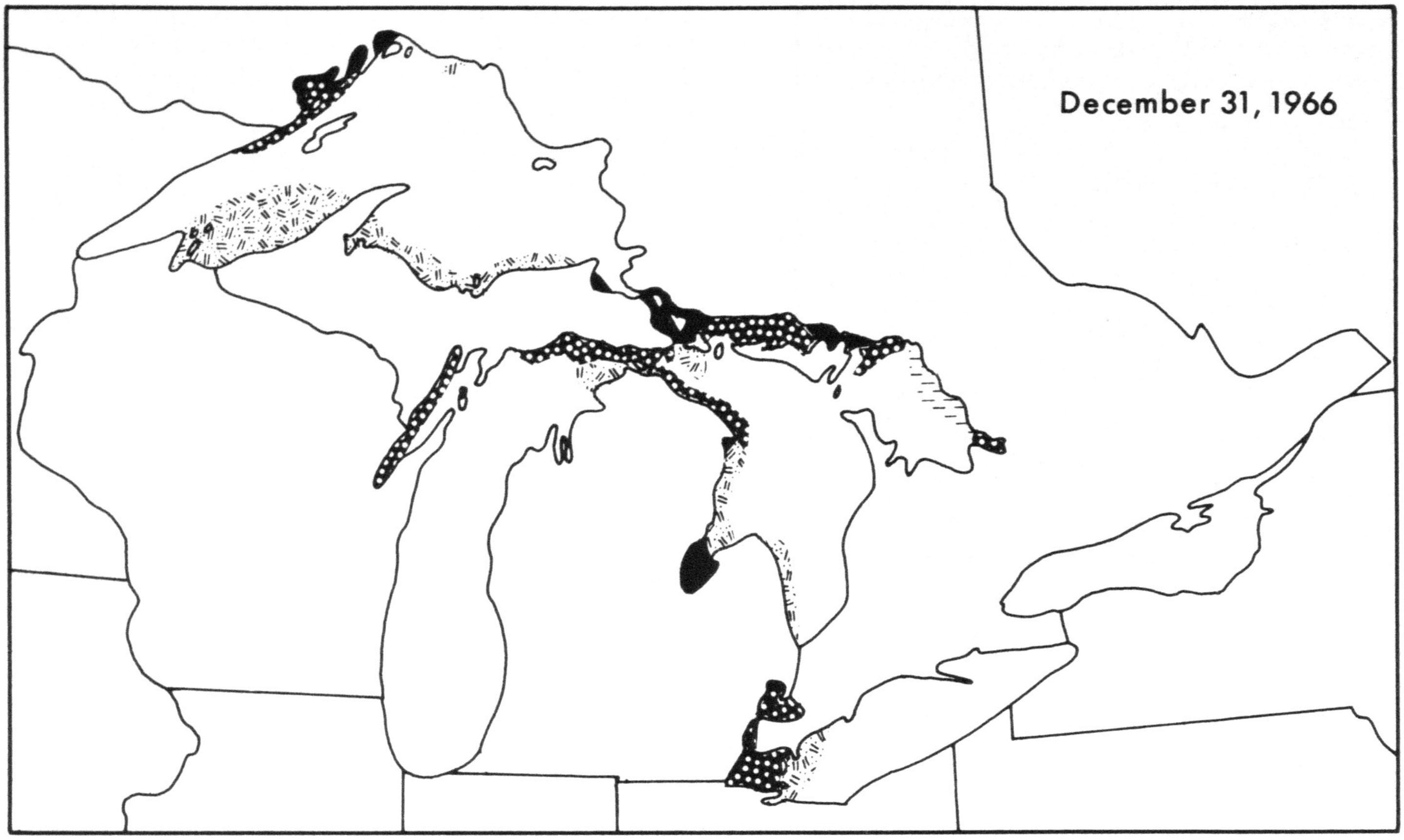

FIGURE 2.—Ice concentration, December 31, 1966. See figure 1 for key relating shading to concentration.

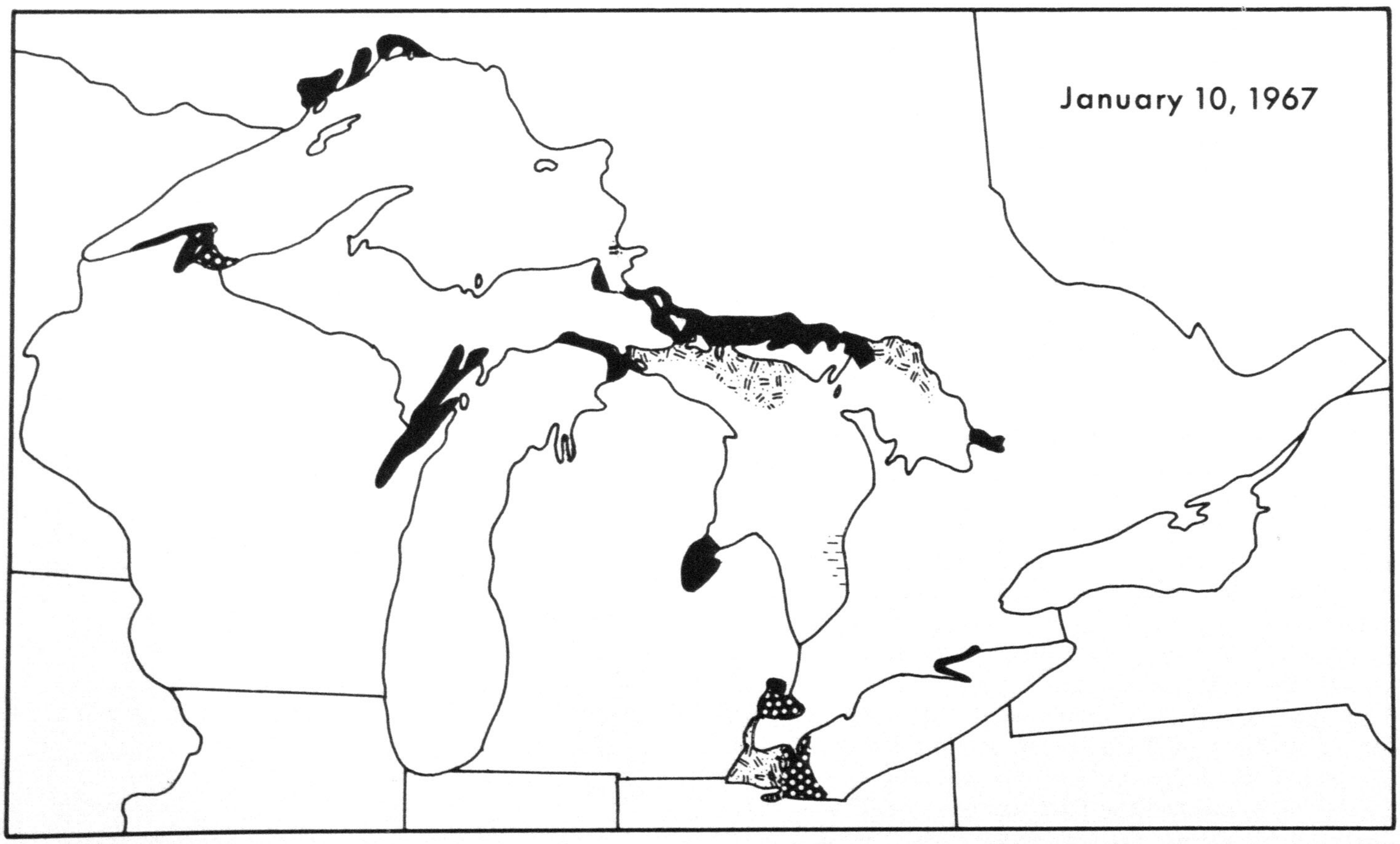

FIGURE 3.—Ice concentration, January 10, 1967. See figure 1.

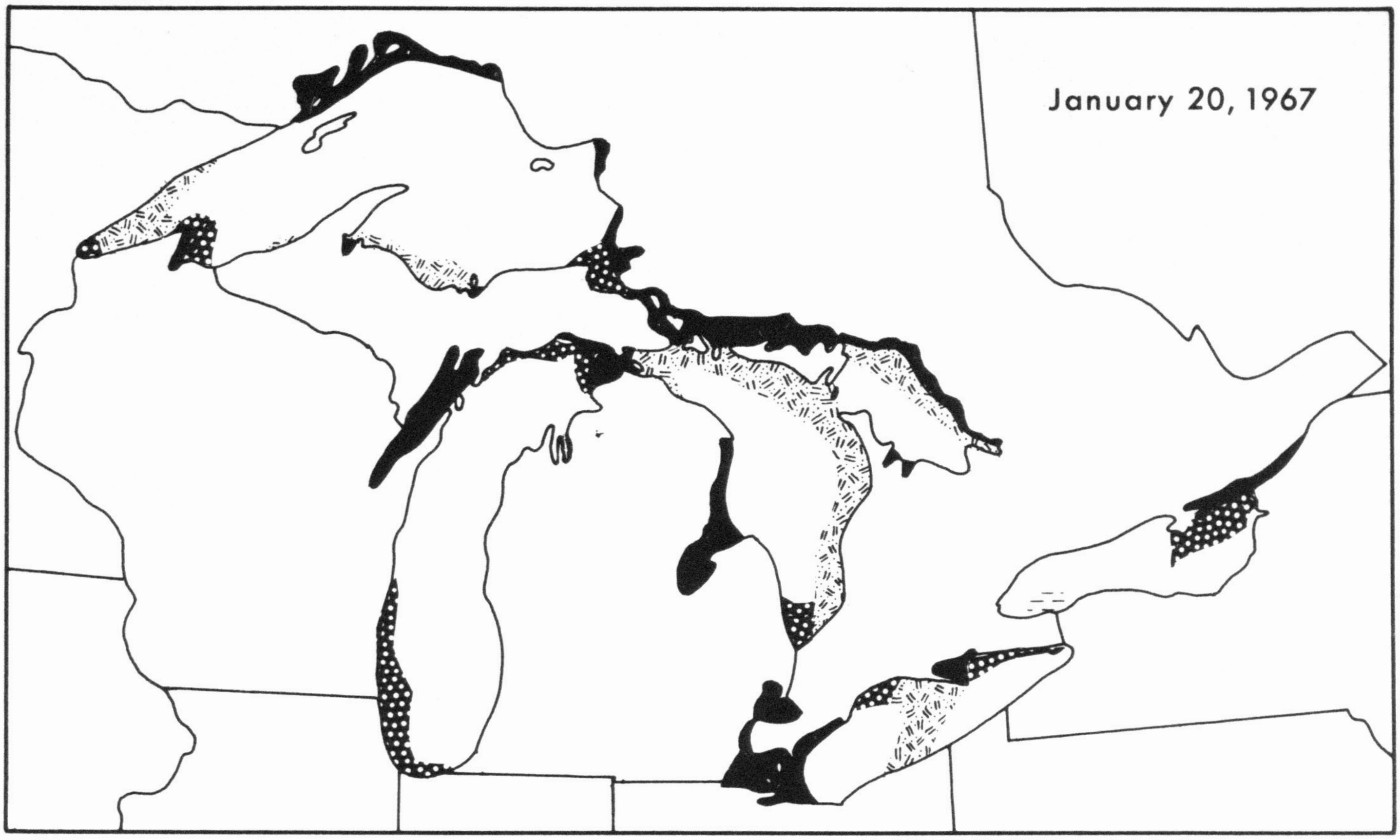

FIGURE 4.—Ice concentration, January 20, 1967. See figure 1.

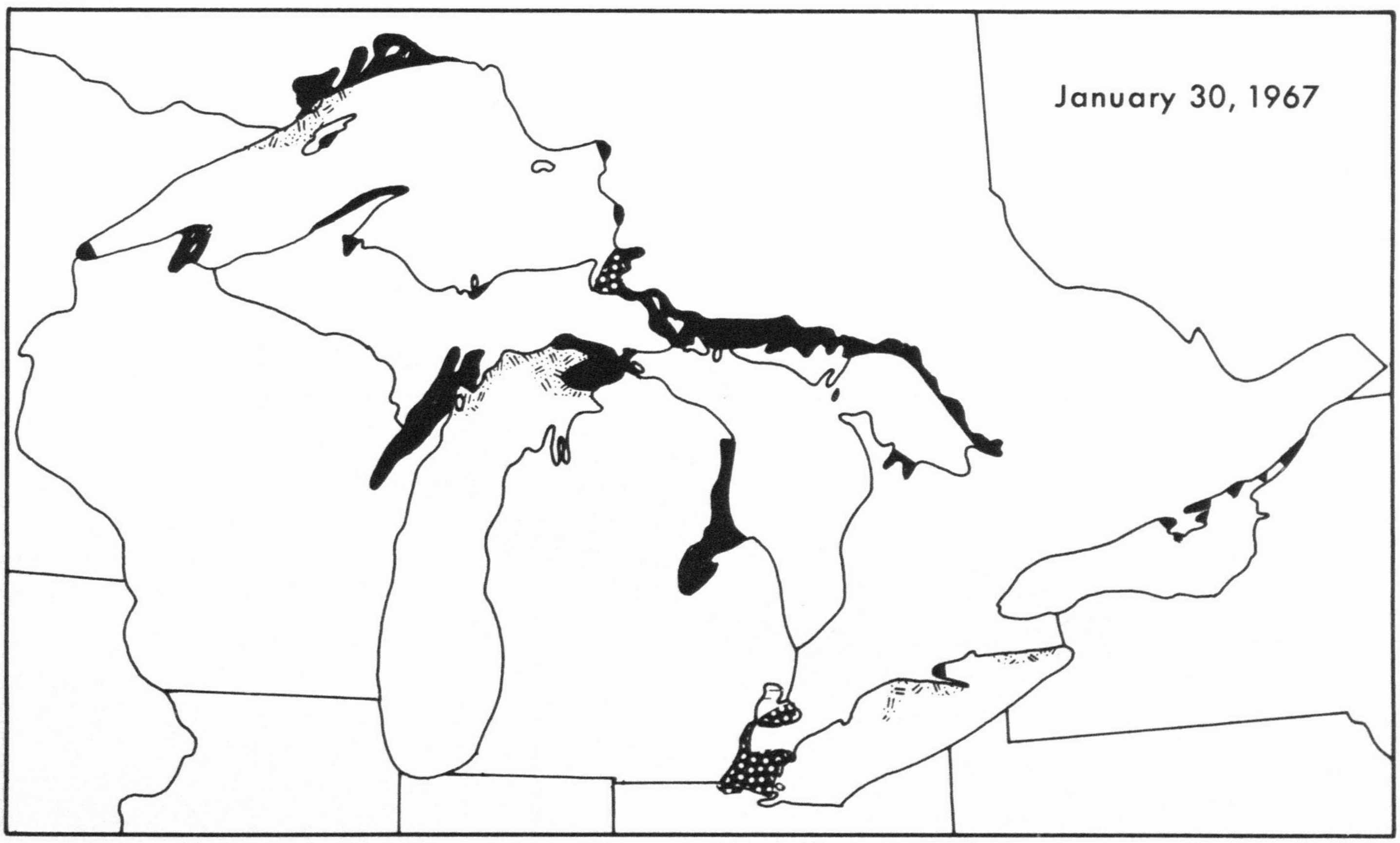

FIGURE 5.—Ice concentration, January 30, 1967. See figure 1.

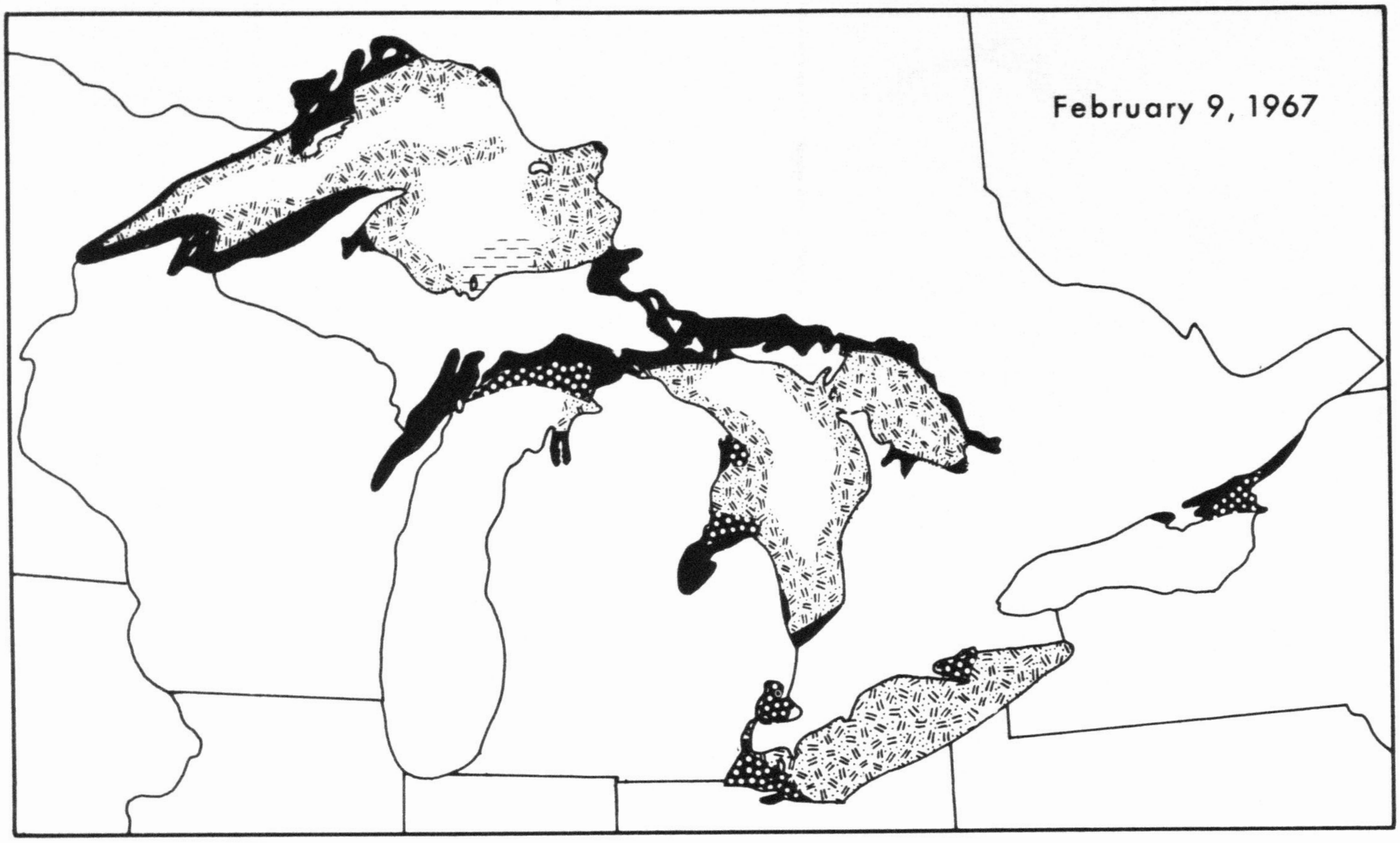

FIGURE 6.—Ice concentration, February 9, 1967. See figure 1.

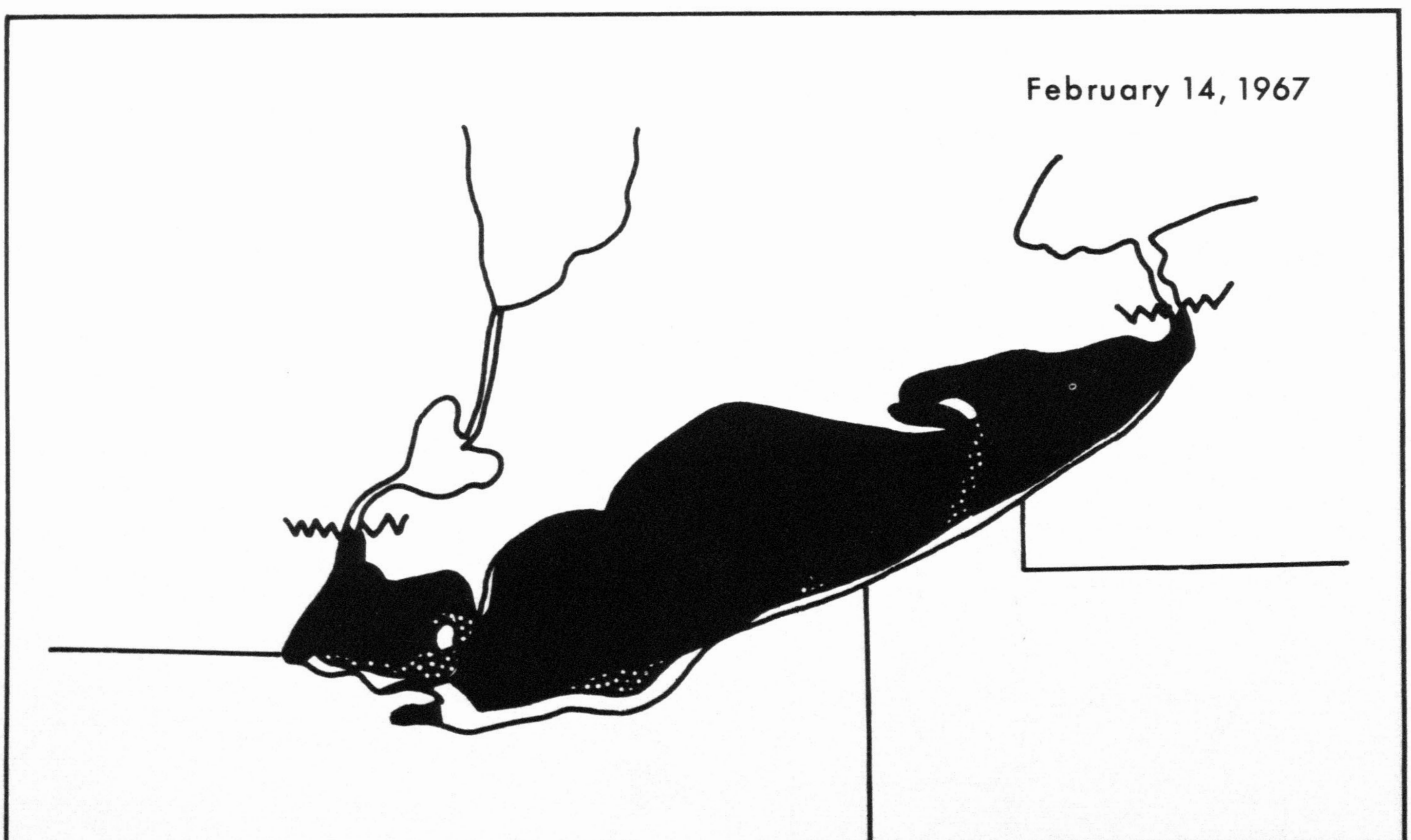

FIGURE 7.—Ice concentration, February 14, 1967. See figure 1.

FIGURE 8.—Ice concentration, February 19, 1967. See figure 1.

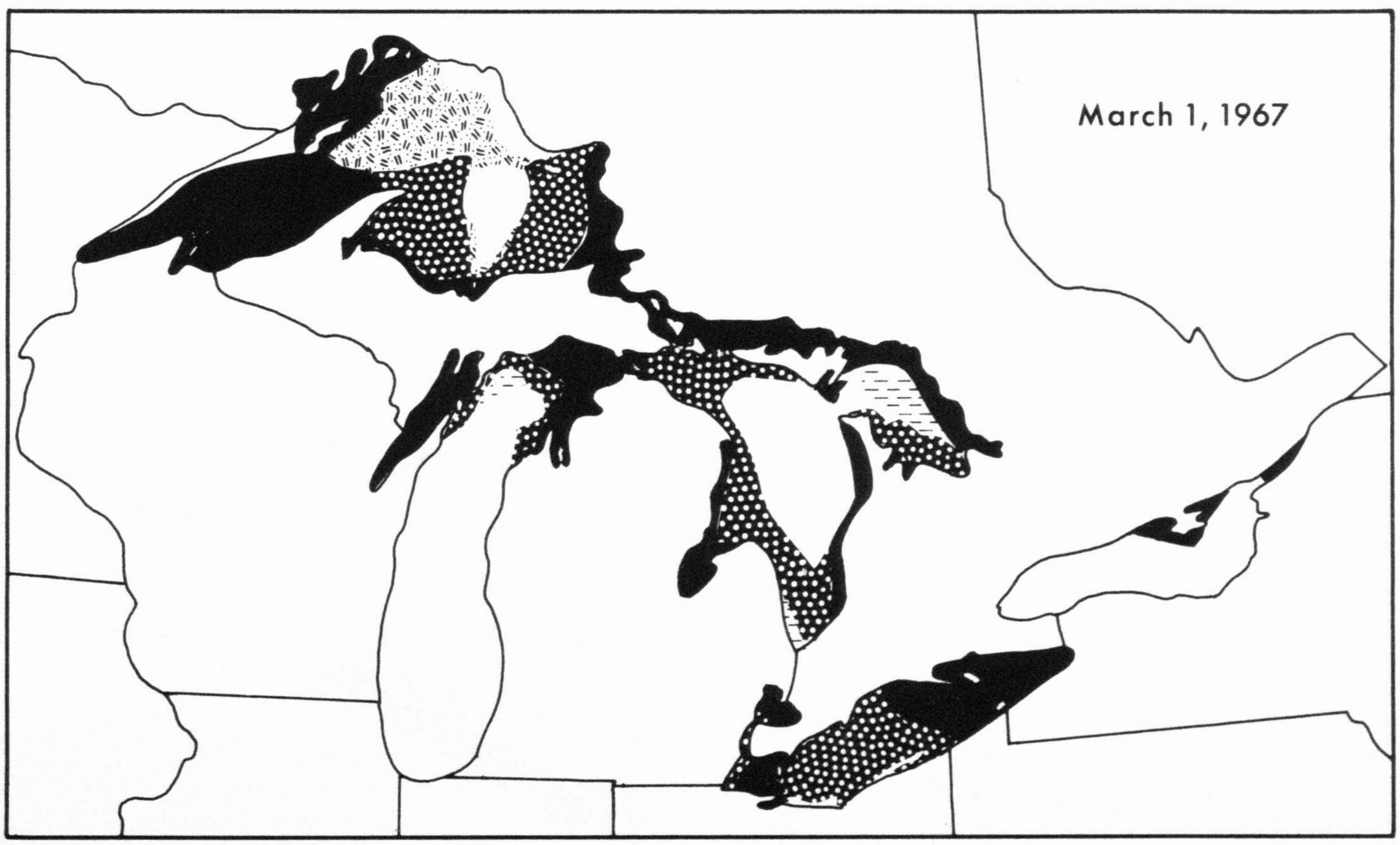

FIGURE 9.—Ice concentration, March 1, 1967. See figure 1.

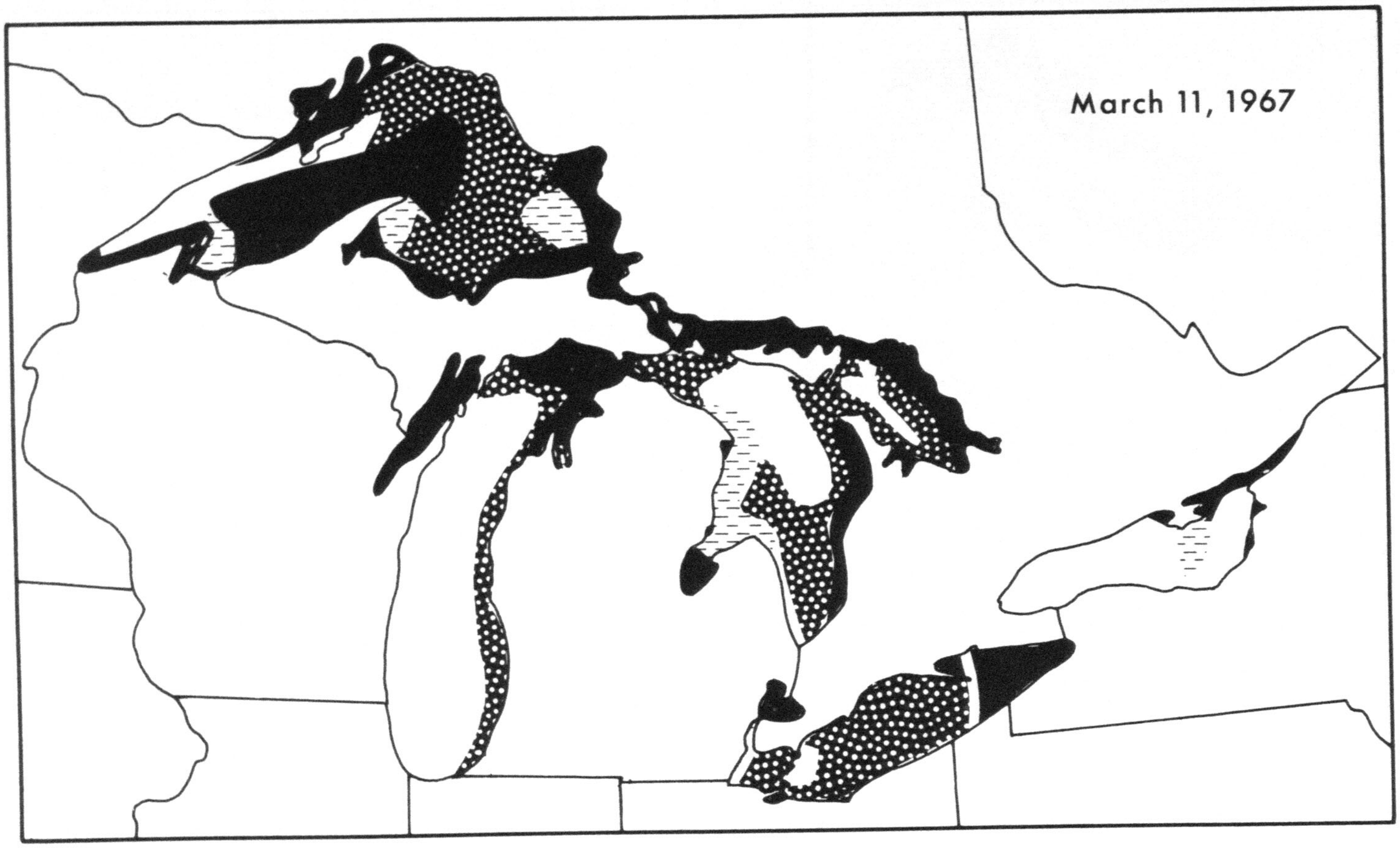

FIGURE 10.—Ice concentration, March 11, 1967. See figure 1.

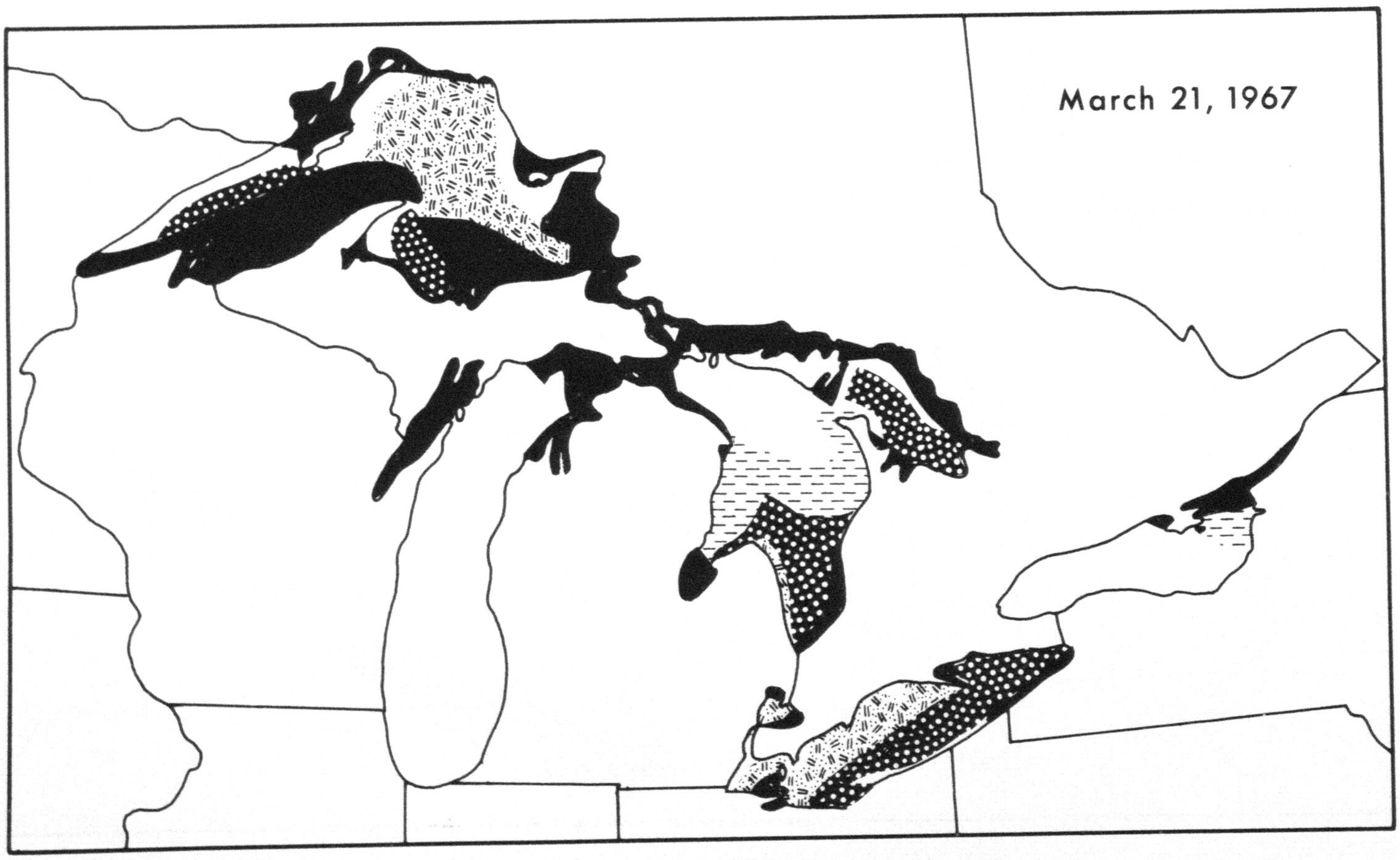

FIGURE 11.—Ice concentration, March 21, 1967. See figure 1.

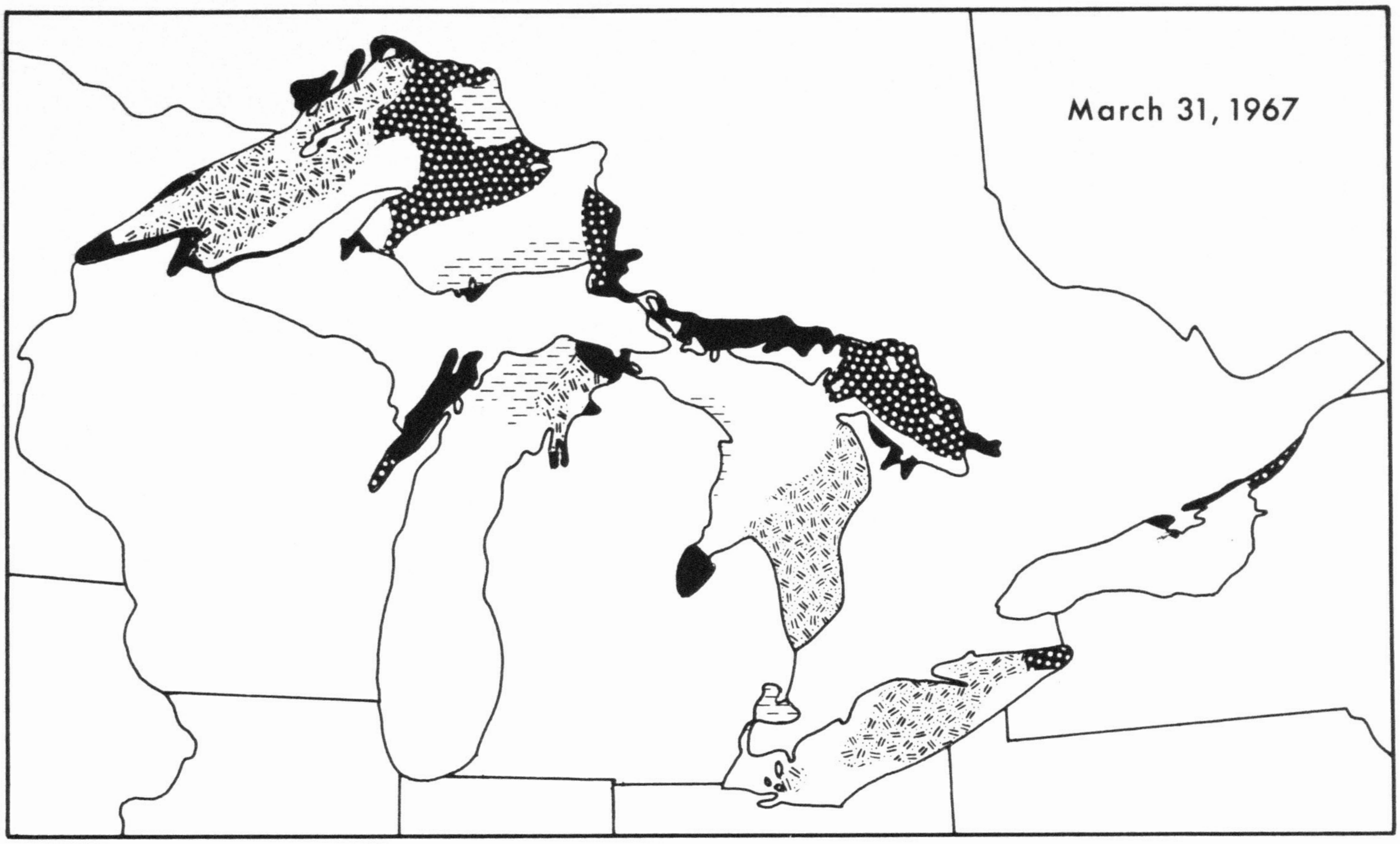

FIGURE 12.—Ice concentration, March 31, 1967. See figure 1.

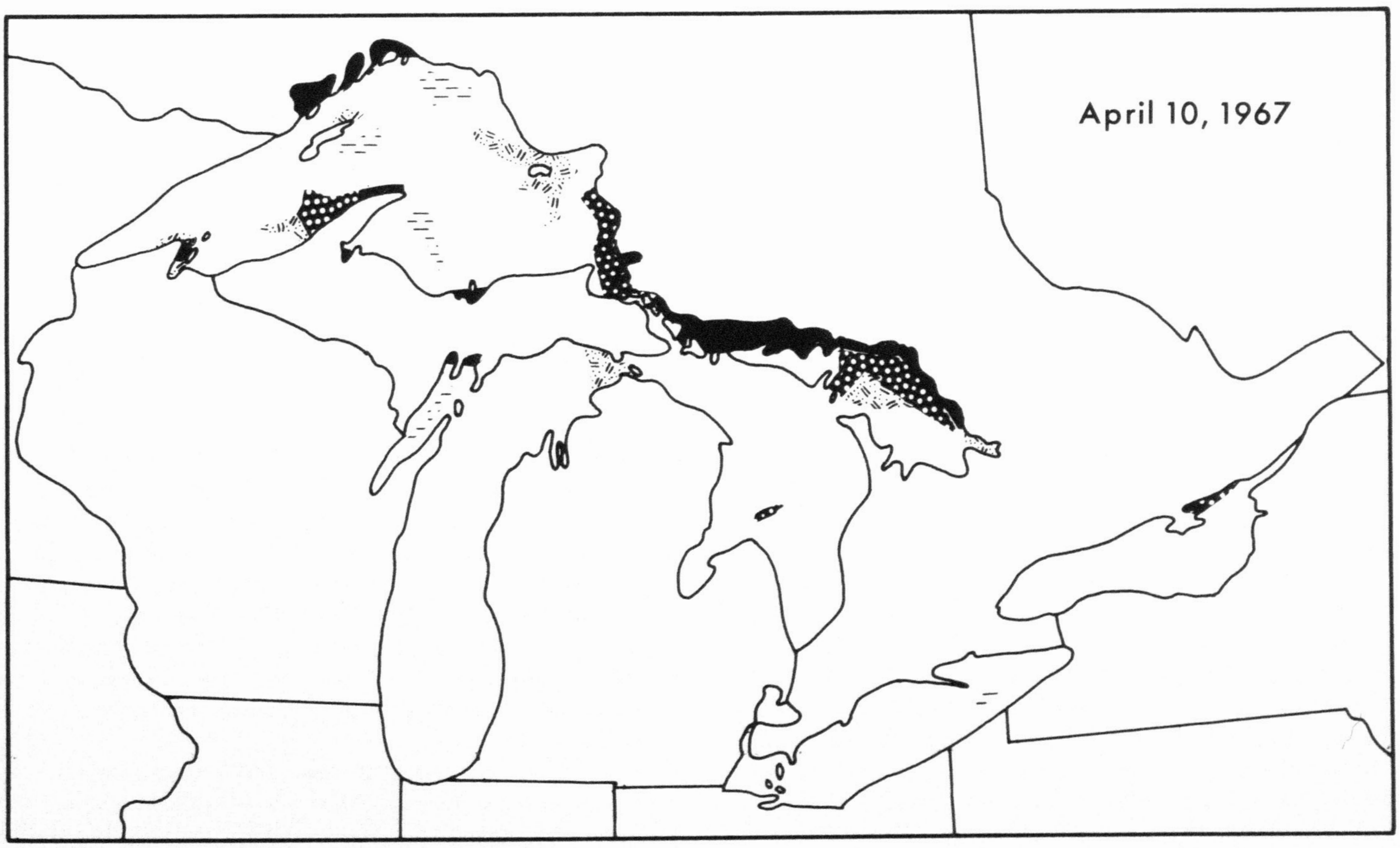

FIGURE 13.—Ice concentration, April 10, 1967. See figure 1.

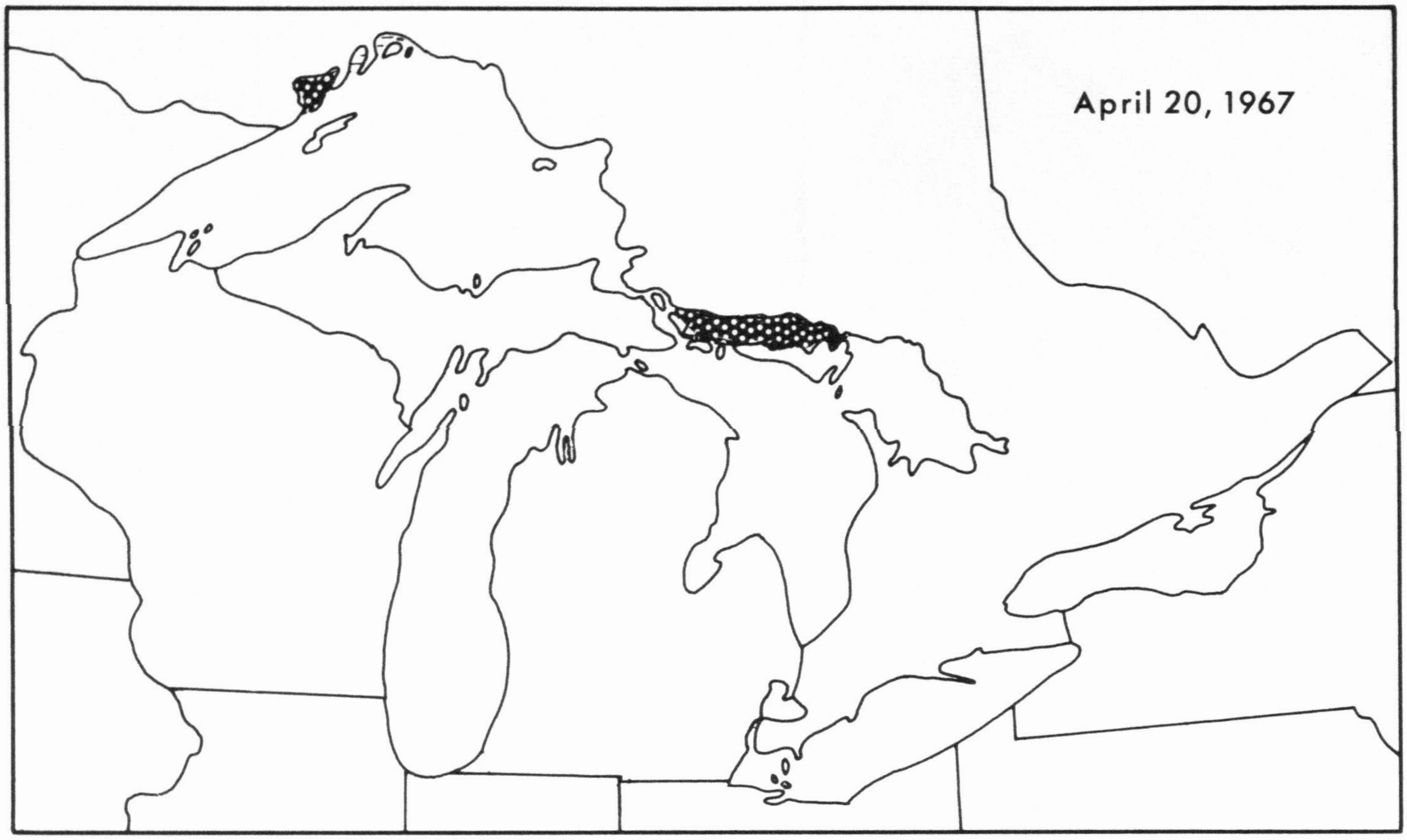

FIGURE 14.—Ice concentration, April 20, 1967. See figure 1.

Ice cover increased gradually with seasonably low temperatures and relatively light winds up to January 16. On the 13th ice thickness was measured as 8 to 13 in. on shallow portions of the northern bays and 3 to 6 in. in areas where ice had formed more recently. The very cold weather of January 17 to 19 thickened existing ice and formed new floes. (See figure 4.)

High temperatures and occasional strong winds prevailed over the Lakes from January 20 to January 25. Most of the drift ice disappeared. A heavy snowstorm on the southern Lakes on the 26th initiated another period of cold weather, but strong winds prevented much increase in ice coverage before the 30th. (See figure 5.)

Cold and calm conditions during the first week in February brought a substantial increase in ice coverage. The chart for February 9 (fig. 6) furnished the earliest strong suggestion that 1967 would have more ice than the average season.

Cold weather continued through mid-February. On February 14 Lake Erie was 95 percent covered (fig. 7). A storm on the 15th and 16th cleared the ice from most of Lake Erie and removed some ice from the central sections of other Lakes. It caused much rafting and windrowing in the southern sections of most Lakes. Ice formation continued. By February 19 average coverage was about back where it had been before the storm, and thickness had increased. On February 17 Lake Erie ice was 7 to 9 in. thick; new ice in the St. Clair River was 4 in. thick. (See figure 8.)

The last week in February and the first part of March were again cold and ice cover increased. (See figures 9 and 10.) A band of ice formed along the shores of southern Lake Michigan during the first week in March, but the storm of March 8 through 11 drifted and destroyed most of it.

Cold weather and the formation of new ice continued into the second half of March. (See figure 11.) The first important warm spell came March 25 to 27. Ice deterioration proceeded at a moderate to rapid pace after that date. (See figures 12–14.)

Ice thickness reached 38 in. at Lakehead. Ports in southern Lake Superior had 18 to 26 in. Drift ice in the Lake varied up to 24 in. Ice in the St. Mary's River and along the north shore of Georgian Bay was reported 15 to 19 in. Green Bay varied from 14 in. in the south to 24 in. in the north. Ice 15 to 20 in. thick formed in the Straits of Mackinac, and 8 to 12 in. in Saginaw Bay. Floes in other areas seldom exceeded 7 in. in thickness, but windrows often piled up to several feet. Maximum ice thickness at most places came during the third week in March.

The winter of 1966–1967 was colder than normal, and ice cover on the Great Lakes was more extensive than normal. Most ports and waterways opened late, but not as

TABLE 1.—*Reports from stationary ice reporters, March 16–21, 1967*

Date	Location	Thickness (inches)	Remarks
March 1967	Lake Ontario:		
17	Fair Haven, N.Y.	9	Lake and channel clear, harbor fast.
17	Kingston, Ont.	10	Ice is solid, icebreaker has passed through once, ferry operates but still unusable for navigation.
16	Toronto, Ont.	0	Harbor clear, Lake clear.
16	Youngstown, N.Y.	2	Lower Niagara River: shore ice, blue, snow covered, channel open, no vessels operating. Lake Ontario: drift, cake, blue, snow covered, open water visible, no vessels operating.
17	Rochester, N.Y.	0	No ice in area.
17	Sodus Point, N.Y.	9	Lake Ontario: no ice. Sodus Bay: fast, blue, channel open to Sand Point, 80% coverage.
17	Oswego, N.Y.	5	Lake Ontario south shore: no ice. Oswego Harbor: fast, floe, windrow, closed craft.
17	Trenton, Ont.	17½	Bay of Quinte, Long Reach, Prince Edward Bay: fast, blue. Adolphus Reach: fast, blue, with large cracks. North Channel, Kingston Harbour: fast, blue.
	Lake Erie:		
18	Dunkirk, N.Y.	0	Ice field beyond vision, large open spaces showing, ice moving with the wind.
20	Buffalo, N.Y.		Buffalo outer harbor fast frozen 2 in. From Buffalo to limit of vision Lake fast field blue windrowed 14 in. Icebreakers.
17	Port Burwell, Ont.	5–6	Ice deteriorating in harbour, partially broken up by fish tugs. Fast shore ice extends out several hundred yards, then open water to approx. 2 mi. out in Lake with small drifting fields in the open water. Ice in Lake appears to be hi h windrows.
17	Port Colborne, Ont.	17½	Fast blue ice field from shoreline Port Colborne Harbour to approx. 1 mi. beyond breakwall, then open water. Distance of open water approx. 5 mi. across in all directions. Small amount of cake ice in the open water areas.
18	Alexandria Bay, N.Y.	8–14	Some open water variable with winds. Fast ice out from shore 500 ft. Wetting up daytimes.
17	Erie, Pa.	3	Ice in Erie Harbor: drift flow white 3 in., 2%. Erie Channel: no ice. Lake Erie: drift floe white 4 in., 5% immediate area.
15	Conneaut, Ohio	9	Solid ice beyond vision but seems to be very rotten.
17	Cleveland, Ohio	8	Cuyahoga River. clear. Cleveland Harbor: 8-in. windrow. Lake Erie: fast, field, blue, windrow 50 in., 2-in snow.
17	Kelleys Island, Ohio	7	South and east: open. West and north: fields of floating ice.
17	Toledo, Ohio	?	Negative ice in the Maumee River. Maumee Bay unknown.
17	Monroe, Mich.	1	Thick ice in the bay has all moved out, now refrozen over with thin ice ½ to 1 in. thick. Stoney Pt. and State Park no ice.
	Lake St. Clair:		
17	Harsens Island, Mich.		Drift, pancake, rotten, windrow. Icebreakers operating, heavy drift ice.
	Lake Huron:		
18	Port Huron, Mich.	8	Huron Cut Channel northward: fast, field, blue, windrow 85% 12 mi. Navigation possible with icebreakers only.
17	Goderich, Ont.	14	Some sign of deterioration.
17	Wiarton, Ont.	12–14	Open water outside islands.
17	Collingwood, Ont.	18–19	Blue ice.
16	Port McNicoll, Ont.	17	Blue ice with 2-in. frozen slush on top, solid to beyond vision.
16	Owen Sound, Ont.	4–6	Ice to beyond vision, 4–8 in. thick.
17	Mackinac Island, Mich.	15	Round Is. to bridge, fast pancake, 14 in., 9% coverage. Round Is. to Bois Blanc, fast pancake, 10% coverage.
18	Mackinaw City, Mich.		Open water still extends from Poes Reef eastward into Lake Huron beyond vision except for considerable drift ice. From Poes Reef westward solid ice extends entire length of Straits into Lake Michigan to beyond vision.
21	Calcite Harbor, Mich.		Ice fast in Harbor, outside ice beyond vision, some windrows noticeable.
17	Alpena, Mich.		Loose floes of ice. We expect Crapo to arrive at 5:30 p.m. today.
17	East Tawas, Mich.		Tawas Bay: 75% open water, field moving toward Gravelly Shoals, 25% fast field blue, 10–14 in. Lake Huron Taw^s Pt. to Au Sable Pt.: drift cakes white intermixed with slush, navigation unobstructed, fish tugs operating.
17	Essexville, Mich.		Ice breaking up in Saginaw River. Saginaw Bay covered with snow-covered ice. Some windrows of ice approx 1 mi. offshore.
18	Harbor Beach, Mich.	4–6	Harbor: fast field blue 4–6 in. thick, 3-in. snow cover 100% coverage. Lake Huron: Drift field blue 6–10 in. thick 80% coverage.
17	Port Sanilac, Mich.	2½	Ice on Lake, some parts covered with snow.
	Lake Michigan:		
16	Harbor Springs, Mich.	13–15	Solid blue ice. Medium snow cover.
17	Northport, Mich.	12–14	Grand Traverse Bay heavy windrows. All harbors 12–14 in.
17	Frankfort, Mich.	6–8	Harbor: fast field blue, 8/2, 10, difficult. Lake Michigan: drift pancake white, thickness unknown. Ex tend 250 yd. offshore. Ice moving in and out of harbor with change of wind.
17	Manistee, Mich.	10	Manistee Lake: fast field blue, full coverage. Manistee River: drift pancake white, full coverage. Lake Michigan: windrow shore ice, unobstructed.
18	Ludington, Mich.		Pere Marquette Lake: 12–16 in. to beyond car-ferry docks partially rotten ice. Ludington Harbor: some floating cakes. Lake Michigan between Ludington, Milwaukee, Manitowoc and Keewanee: open water.
17	Muskegon, Mich.	2–4	Muskegon Lake: fast floe blue, 30% coverage. Muskegon Channel: unobstructed. Lake Michigan: shore ice only.
17	Grand Haven, Mich.		Fast ice on shore extending into Lake 200 ft. Channel and Lake open beyond vision.
17	Holland, Mich.	6	Lake Michigan: fast field blue, 9 steamers. Holland Channel: drift brash, 5 steamers. Lake Michigan: unobstructed with shore ice all the shoreline.
17	South Haven, Mich.	0	No ice in Lake, fish tugs operating.
17	St. Joseph, Mich.	0	St. Joseph Channel: no ice. Lake Michigan, from channel entrance to limits of visibility: drifting brash white, 1 in. of ice 10 in. of snow, with some open areas, unobstructed to shipping.
17	Michigan City, Ind.	10	Michigan City Channel: drift floe white jammed ice extends into Lake estimated 4 mi. thickness 5 in. with 5 in. of snow.
17	Calumet Harbor, Chicago, Ill.		No ice in Harbor or Channel.
17	Chicago, Ill.		Chicago Channel and Outer Harbor: no ice. Lake Michigan: no ice.
17	Waukegan, Ill.		No ice.
18	Kenosha, Wis.	1–2	Fast, blue, fish tugs operating, harbor 100% coverage of thin broken ice, Lake clear beyond breakwater.
16	Sturgeon Bay, Wis.		Varies from 18 in. by the bridges to 36 in. outside of Shorewood Point.
17	Sturgeon Bay Canal, Wis.	28/10	Sturgeon Bay Canal entrance to Lt. 7: unobstructed. Lt. 7 to Sherwood Pt.: fast, blue, icebreakers, 28/10. 10. CGC Mesquite running twice weekly. Lake Michigan: unobstructed.
17	Green Bay, Wis.		On the Bay of Green Bay there has been no significant change in the ice. Much of the ice continues around 14 in. with here and there, in shallow waters ice up to 18 in. while in deeper waters the depth runs to 11 in. The Harbor of Green Bay froze over again on Thursday with a thin film of ice.
17	Menominee, Mich.	14	Solid snow covered.
17	Escanaba, Mich.	20–24	Solid blue. no open water visible.
16	Plum Island, Mich.		Detroit Harbor was open to ferry dock. 1-in. slush from snowfall north of Washington Island into Rock Island. St. Martin's Passage: fast field blue 23-in. ice 6-in. snow. Port de Morts Passage open to 1 mi. N. of Plum Island.
	Lake Superior:		
17	Whitefish Point, Mich.	11–22	Fast field blue windrow 10–18 in. in shipping lanes.
17	Grand Marais, Mich.	21	Harbor: fast 21 in. blue. Channel: fast 19 in. blue windrow at entrance to Lake. Lake Superior: jammed ice extending from shore to beyond vision.
17	Munising, Mich.	22	Fast field blue ice beyond vision. Snow cover 6 in.
17	Marquette, Mich.	8	Ice in harbor is approx. 8 in. thick, with 1 in. of snow coverage. Fast field blue. Icebreakers. Shore ice along Lake (about 10-in. coverage visible from here).
16	Keweenaw Lower Entry, Mich.	18–24	Ice fields extend as far as the eye can see. Very little deterioration along shore.
17	Eagle Harbor, Mich.	24	Ice beyond vision.
20	Ashland, Wis.	25	Fast blue.
20	Superior, Wis.		Fast blue 20 in. both land end and center and 26 in. outer end of slips.
20	Duluth, Minn.	18	Fast field blue with 1-in. snow cover. Icebreakers. Lakeward: fast blue 8 in., no snow, difficult, extends beyond vision.
20	Grand Marais, Minn.	16	Fast field blue jammed, no snow, difficult—shore ice in Lake.
16	Port Arthur, Ont.	37½	Ice solid from Lakehead shore to Isle Royale. Lake Superior reported 80–90% ice covered. Kam River has 20 in. solid ice with no deterioration. 34–42 in. in Port Arthur elevator slips. Air Canada captain reports eastern half Lake Superior better than 75% ice covered with only small breaks observed. Stretch open water the width of Isle Royale extends from Isle Royale 35–40 southward with wind driven packed ice piling up on its southern edge.

late as the correlation charts in use indicated. Earlier than expected openings are attributed to 1) thinner than average ice in most of the northern regions and 2) aggressive action on the part of shipping companies and their supporting icebreakers.

5. CONCLUSIONS

Information now available makes possible useful analyses of Great Lakes ice coverage, but not on a real time basis. Further efforts at data acquisition, and especially data standardization, would be helpful, but a greater gain could probably be achieved by expending the same effort on more rapid data transmission and electronic data processing. Some success has attended efforts at artificially lengthening the navigation season. Plans have been discussed for greatly increasing those efforts. If these plans are to meet with success, we must find a better understanding of nature's own handling of the ice.

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